Update on SOST minke whale hearing project

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Setup

Norwegian partners arrived at the field site in Lofoten May 17th-21st. US collaborators arrived on 22 May. Critical equipment transported from the US was lost by the air carriers in transit, but was delivered to the field site on 25 May. Placement of barrier nets, the fish farm, and installation of the barrier nets began on 23 May. This initially involved the transport of the net containers, transfer of nets to the purse seine ship (including net repair at the time of transfer), and placement of the barrier net over a period of days. Approximately one day of deployment was lost due to the purse seine ship entangling a barrier net in its propeller that required the vessel to be towed to port for repairs. Modifications to the catch basin included: incorporation of a quick-release locking mechanism to the basin door, addition of anchors to support the barrier nets, and the relocation of anchor points. Completion of the "whale trap" occurred on ~31 May, although adjustments continued until 2 June.

Whale Sightings

The full team arrival occurred by 31 May at which point a brief was held for all participants on the goals of the project and the mechanics of the catch procedure. The team did not have an auspicious start: three low-pressure systems sequentially entered the region starting on 3 June and continuing through 7 June (Figure 1). The systems brought high wind and unworkable sea conditions and broke the attachments of one of the barrier nets (fortunately found floating within the capture basin). Upon the passing of the low-pressure systems, the barrier net system was repaired and the team began to monitor for whales.

Only three minke whales were observed in the region of the catch basin from 8-12 June, which was concerning for the team. However, beginning on 13 June, more whales began to be observed in the area with a large increase in sightings occurring over the next week. As of the 18 June, 30 whales were sighted with 27 whales sighted over a five-day period. This far exceeds the number of whales sighted in 2021, even though we have lost more days to bad weather this year. The majority of the animals sighted are of the size category we are targeting.

Fourteen of the 30 sighted whales came in close proximity of the catch basin, with nine approaching the catch basin door. The first four animals that approached the door changed direction at the door and exited the area to the east. This required the team to investigate and make modifications to the catch basin door (see Lesson Learned #1). Within six hours of the modifications, the first whale was caught (16 June). A second whale was caught the following day (17 June). These are described in more detail below. Multiple whales came up to the catch basin door while animals were already captured within. We estimate that we could have caught five or six whales within 2-3 days had we not been constrained by the whales already caught.

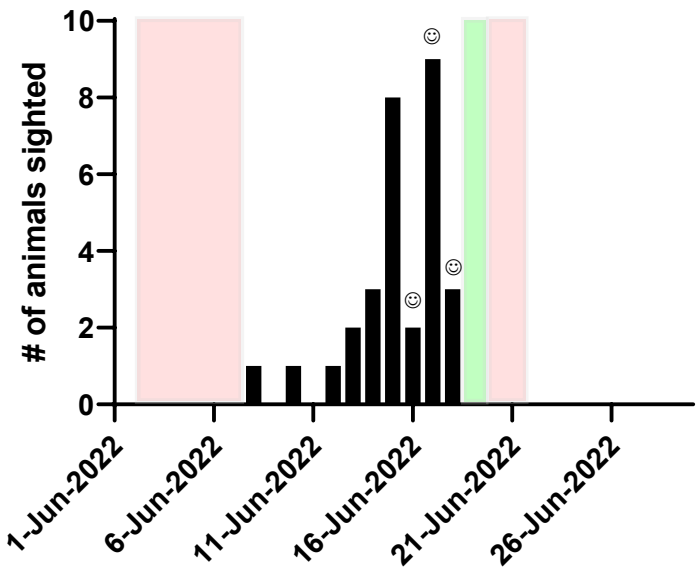

Figure 1. Number of minke whale sightings as a function of date. The red-shaded regions correspond to bad weather days that prevented personnel from being on the water. Five days were lost at the beginning of the period due to three low pressure systems that sequentially entered the region. The green-shaded region corresponds to a day where the full team was allowed to recover after a period of 48-72 hrs where captures and attempted testing occurred; most personnel had disrupted sleep cycles with minimal sleep during this time. The smiley faces correspond to days of basin capture, attempted corralling of animals into the fish farm, and attempted testing of minke whales (n=2).

Lesson Learned #1

We found it odd that four whales made it to the door of the catch basin and then turned around. One suggestion why there was a change in behavior was that the metal mechanism associated with new door latching system was possibly making noise underwater (metal on metal). The team placed a SoundTrap on the B-line (net on east end of the catch basin) and monitored underwater sound over their watch. Analysis of the data indicated that there was a continuous “jingling” of metal on metal at the entrance to the catch basin. The team then removed all metal-on-metal connections by affixing all essential metal parts to rope line. A subsequent SoundTrap deployment verified that the change removed all clanging metal sounds. Within six hours of the change, the first whale was caught. Although anecdotal, it appears that an unintended consequence of trying to make the trap more efficient might have resulted in us making a make-shift acoustic harassment device.

Whale Catch #1 (16 June 2022)

The first whale was captured in the basin at 0350 on 16 June. After the two-hour observation period required by the catch protocol, the whale was deemed suitable for advancing to the next phase of corralling into the fish farm. Unfortunately, the whale did not swim into the fish farm of its own accord and seemed to avoid the area of the fish farm entrance. The day team was therefore rallied and arrived onsite to start the corralling process. Corralling began at 0721 with support boats entering the basin. The first 30 min were used to see if animal would react to the boats and move toward the fish farm in the absence of the corralling net. Animal orientation, swim speed, respiration rate and surfacing suggested that the boats were not sufficiently effective in influencing the animal’s behavior.

The two support boats moved to the corralling net located at the west end of the catch basin and detached it. They then moved eastward along the basin with the boats supporting the north and south ends of the net. A gap on the north side occurred about 2/3 of the way across the basin due to differences in the horsepower of the two boats and variations in the bathymetry. Animal respiration rate was ~1 breaths/min and diving appeared calm during this period.

At 0941, the volume of water was constricted enough that whale began stereotypical circular swimming in a clockwise manner, typically surfacing at the same spot. Typical one-minute dives were occasionally interspersed with dives of two minutes. Animal respiration rate increased slightly to ~1.4 breaths/min.

The corralling process went as planned and at 1001 the whale was constrained to a water volume in front of the fish farm opening that was smaller than the fish farm volume. The whale's swim speed became more vigorous and respiration rate increased again slightly (1.6-1.8 breaths/min). It was becoming apparent at this time that the whale was averse to swimming through the large opening in the fish farm (see Lesson Learned #2). At 1006, the volume was reduced again. The swim behavior remained the same, but at 1011 the animal performed a 4-5 min dive. At 1021, the whale surfaced with an exhalation/shallow breath and dove. It was not seen again within the confined area. Six minutes after the last sighting within the confined area, a team member spotted a whale on the other side of D line (outside of the catch basin).

The immediate concern was that the whale became trapped under the nets. However, no net movement at the surface indicative of entanglement was observed. An ROV and cameras were used to verify that no animal was caught under the net, but it also confirmed that gaps in the barrier system existed where the barrier nets met the fish farm. The team was aware of these gaps from a prior ROV assessment, but did not have the resources available to correct them and moved forward with the hopes that the whales would not have time to find them before they were corralled into the fish farm. Nevertheless, it required the team to take some form of action to prevent escape through these gaps from happening again (see Lesson Learned #3).

Lesson Learned #2

The minke whales (both the first and second) appeared averse to entering the fish farm. The team determined that the decision by the first caught whale to dive and escape through the gaps between the B-line barrier nets and the fish farm, rather than swim through the large door opening into the fish farm, indicated a strong aversion that was not overcome by crowding. After discussion about the corralling event, the team decided to modify the corralling procedure by slowing the process down and allowing the whale to acclimate to reduced water volumes in order to reduce the stress of the corralling event and in the hope that it would eventually decide of its own accord to enter the farm.

Lesson Learned #3

The gaps between the B-line barrier nets and the fish farm had to somehow be resolved. To address this, it was decided that the corralling procedure would be further modified by pulling the ends of the E-line (the corralling net) up along the sides of the B-line barrier nets where they meet the fish farm. This effectively blocks access to the gaps that occur at that location.

Whale Catch #2

The second whale was caught in the catch basin on 17 June, shortly after resetting the trap from the prior whale capture. The animal was contained in the basin and Phase II of the process began at 1635, after the night team had been rallied and arrived onsite. During the two-hour observation period the whale calmly swam around the basin investigating primarily the B-line (eastern barrier line of the basin). Whale respiration rate averaged 0.8 breaths/min during the observation period.

Corralling began at 2019 and followed the same process described for Whale Catch #1, with the prescribed modifications. The process was slowed significantly once the whale was corralled in the northeast corner of the basin near the fish farm and the reduction in water volume started (see Figure 2). At this point, the ends of the corralling net were drawn along the B-lines to cover the gaps at the junction with the fish farm. Once the area was closed off, the corralling stopped and the animal was given 20 minutes to adjust to the new situation. When possible, boat engines were turned off to minimize noise exposure of the animal. As the team prepared to reduce the water volume again and push the whale toward the fish farm door, the whale entered the fish farm. The door to the fish farm was quickly closed and the interior net of the fish farm raised so the whale could not escape. During the first 30 minutes within the fish farm, the whale's respiration rate increased slightly (1.5-1.7 breaths/min) but its swimming behavior continued to be calm and normal. The animal began counter-clockwise swimming once in the fish farm.

Figure 2. The stages of corralling. (A) Support boats detach corralling line from west end of the basin and begin moving it across the basin to the east. (B) As they approach the east barrier net (B lines) the southern support boat turns northward. (C) Both support boats continue northward containing the whale in the smaller volume of water until they are able to connect to the B lines. (D) Corralling nets are pulled up under the fish farm frame to block off the gaps that occur at this junction. The same occurs on the east (top) portion of the door frame.

Because of incoming bad weather that would have prevented moving to the next phase and collecting AEP data, the whale was kept in the fish farm overnight under constant observation by team members.

During this period, the whale's respiration rate ranged from 0.6-1.2 breaths/min and settled into the lower range for most of its time in the enclosure. Swim behavior did not change during the overnight period.

At ~1500 the following day, the team began corralling the whale into the side of the fish farm so that it could be contained in a hammock consisting of the interior net. This is where the AEP testing would occur. The process began with the interior net being raised in a controlled fashion such that the volume of water available to the whale was reduced. Then, three members of the team, including an attending veterinarian and an investigator responsible for the AEPs, boarded a wood raft located in the fish farm. A set of rollers for lifting the interior net was threaded in front of the raft and beneath it (Figure 3). Starting at 1558, the rollers were pulled by other team members from the edge of the fish farm ring while individuals on the platform pulled the net over the rollers. In this fashion, the water volume and surface area of the fish farm was gradually reduced and the platform was pulled toward the animal. Shortly after the platform passed the midpoint of the net, the whale began to show signs of distress with more vigorous swimming. The animal then swam to the edge of the fish farm where it lost attitude control. At this point, it was deemed necessary to quickly close on the whale to gain control of the situation and provide supportive care. Once the whale entered this phase, its breathing became erratic and it continued to show signs of capture shock. The team successfully contained the whale and continued to provide supportive care for approximately 26 minutes in hopes of the animal stabilizing (Figure 4). At 1710, it was determined to let the animal go back to deeper water by releasing it and dropping the interior net. The animal went beneath the surface for ~4.5 minutes after it was released and then surfaced and began swimming as it had prior to the corralling. It quickly returned to the behavior it exhibited within the enclosure and prior to being constrained for testing.

Figure 3. Placement of rollers used to progressively lift the net in the fish farm as it is moved across it. The floating platform carrying several research personnel follows behind the roller and is used to access the whale once constrained in the netting on the opposite side of the fish farm.

The approved test protocol requires that each animal only be constrained once for testing. Given that constraint did occur, it was deemed that the animal should be released back to the wild. The E-line (corralling net) was removed from the fish farm door (thus exposing the openings at the junctions with

the B-lines). The door to the fish farm and the inner net were then lowered in sequence to control the whale's exit from the fish farm. The whale did not immediately leave the fish farm for the basin, but rather continued circular swimming in the fish farm for ~7 hrs. At this point, it swam through the fish farm door and into the basin. It was observed in the basin for five surfacings. Its last surfacing was next to the fish farm door and then it was no longer observed; the whale appeared to have found the same exit as the previous whale.

Figure 4. Minke whale supported in fish farm net with ECG electrodes being attached.

The team had a debrief the following day to discuss the protocol implementation and outcome. Even though the team successfully caught a whale and put it into position for the AEP hearing test, it was apparent that modifications to the procedures are needed to minimize the potential for capture shock (see Lesson Learned #4 and #5).

Lesson Learned #4

The species we are working with may be particularly susceptible to capture shock, as has been recently observed in the Vaquita. As such, we need to be careful to mitigate capture shock and any progression toward capture myopathy. The team reevaluated its corralling procedures and has determined that future corralling and handling in the fish farm will be taken slowly with stops during the progression to let the animal acclimate to reductions in water volume and the presence of people. We have permission to hold animals for up to four days and we would rather be patient with the process and get good data rather than rush the process at the risk of compromising animal welfare. The location and job assignments of personnel were modified in order to correct deficiencies observed during the first capture attempt (e.g., managing the net for support and orientation of the whale and research personnel on the raft).

Lesson Learned #5

It became apparent after review that the original plan of performing procedures in a serial fashion should be altered. Nearly all of the procedures can be run in parallel and there was sufficient time to place electrodes and record at least auditory brainstem responses from the subject during the

supportive period. Procedures like ECG placement, blood draws, and satellite tag attachment can occur at the same time (provided there is sufficient support for the whale). The latter objective of getting a satellite tag on the whale has been elevated in importance since it is not good for the animal welfare objectives that we cannot track animals once they have been released.

Conclusion

We are excited that we caught two whales and were able to successfully maneuver one into position for the hearing test. The rapid onset of capture shock was surprising, but can be mitigated, and we do not anticipate that it will necessarily be the same for all individuals within a species (e.g., young male bottlenose dolphins are the most prone to this kind of distress when wild-caught). We hope to have another capture before the end of this season so we can implement our protocol changes as we did between the first and second captures of this year. We have learned a lot this season and continue to grow our knowledge of how to deal with this species. We believe the audiogram is coming, but we must be patient with a process that requires maintaining animal health in the near absence of relevant data from live captures.